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(56) Documents Cited
US 5051799 A US 4395593 A

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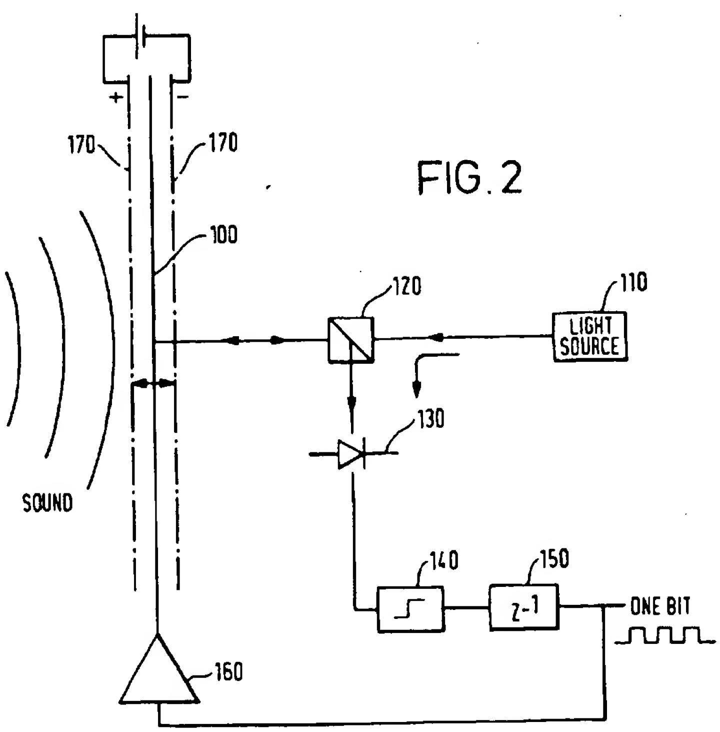
(54) Abstract Title

Single-bit microphone

(57) The microphone directly outputs a one-bit digital audio signal without the use of an A-to-D converter. Motion of the microphone's diaphragm 100 is detected by an optical interferometer 110, 120, 130. The output of the interferometer passes to a thresholder 140 and a delay 150 to produce a one-bit output signal. The one-bit signal also passes to a diaphragm driver 160 that drives the diaphragm in an opposite sense to the motion represented by the one-bit signal.

FIG. 2



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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

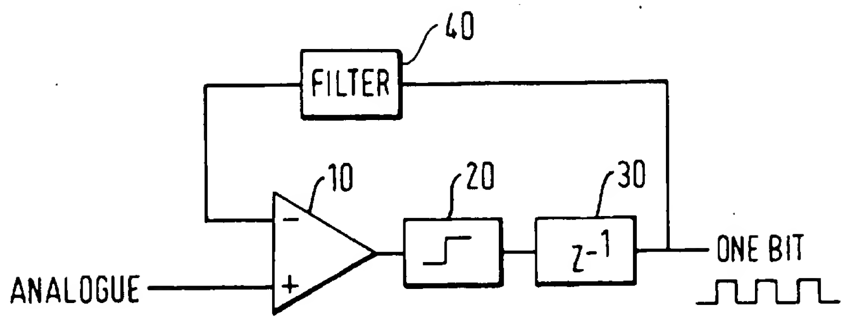
40
FILTER
10
20
30
ANALOGUE
z^{-1}
ONE BIT

FIG. 1

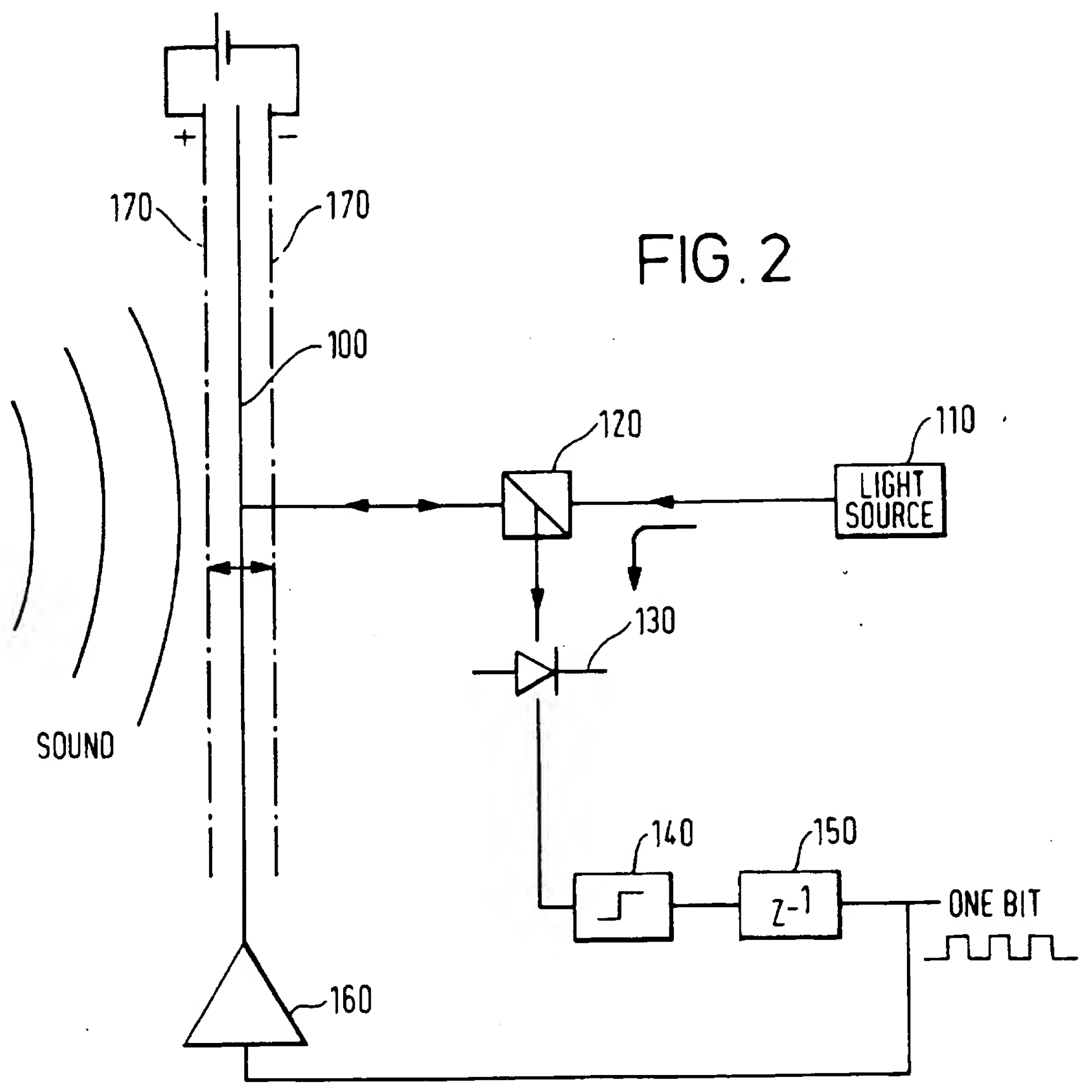
170
170
100
120
110
LIGHT SOURCE
130
SOUND
140
150
z^{-1}
ONE BIT
160

FIG. 2

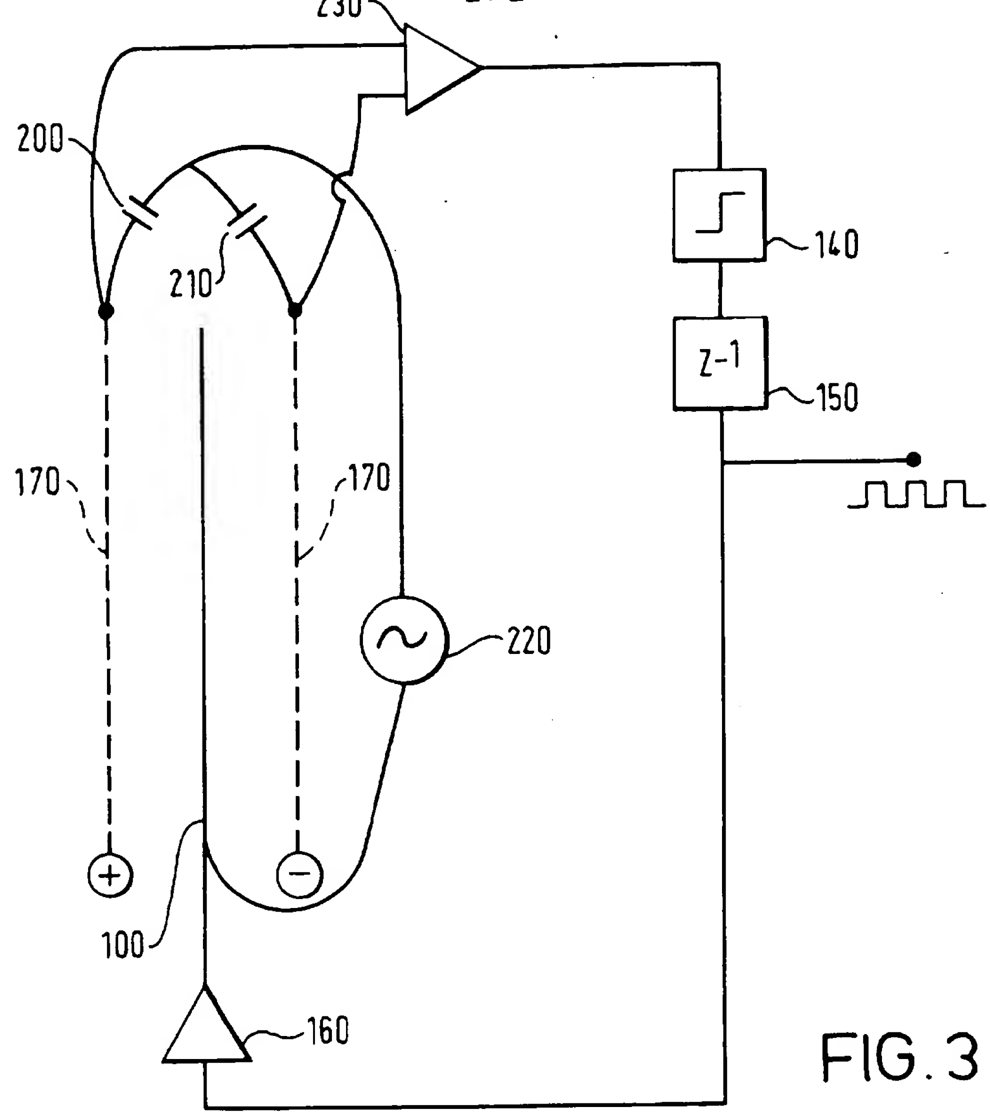
230
200
210
140
150
Z-1
170
170
220
+
−
100
160

FIG. 3

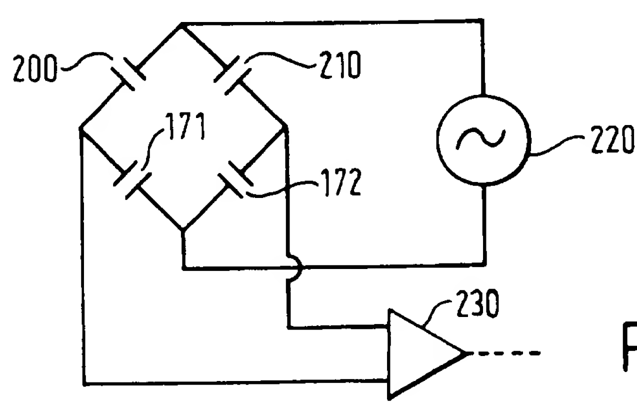
200
210
171
172
220
230

FIG. 4

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MICROPHONE

This invention relates to microphones.

Known microphones convert an analogue sound waveform (i.e. physical variations in air pressure) into an analogue electrical audio signal. If a digital audio signal is required, the analogue signal has to be converted by a digital to analogue converter (DAC) into the digital audio signal.

This extra stage of analogue to digital conversion requires extra components and, more importantly, is not a lossless process. In other words, some of the information contained in the original analogue audio signal is lost by the conversion process, through conversion errors or noise.

It would be desirable to provide a microphone which generates a digital audio signal directly from the air pressure variations representing the actual sound.

This invention provides a microphone comprising:

a diaphragm movable in response to incident sound waves;

a position sensor for generating an electrical position signal indicative of the position of the diaphragm;

a thresholder for generating a one-bit digital signal indicating whether the position signal is above or below a threshold signal level;

a delay for delaying the digital signal; and

a diaphragm driver for moving the diaphragm in response to the digital signal and in an opposite sense to the motion of the diaphragm represented by the digital signal.

The invention will now be described by way of example only with reference to the accompanying drawings, throughout which like parts are denoted by like references, and in which:

Figure 1 is a schematic diagram of a delta-sigma modulator;

Figure 2 is a schematic diagram of a microphone according to a first embodiment of the invention;

Figure 3 is a schematic diagram of a microphone according to a second embodiment of the invention; and

Figure 4 is a schematic equivalent circuit to a part of Figure 3.

A known delta-sigma modulator is illustrated in Figure 1. An input analogue signal is supplied to a comparator 10 and from there to a feedback loop comprising a thresholder 20, a delay 30 and a filter 40. A one-bit signal representing the analogue signal is output by the delay 30.

The microphone according to embodiments of the invention uses a similar principle to generate a one bit signal directly from physical sound vibrations.

In Figure 2, a diaphragm 100 vibrates in response to incident sound waves. The motion of the diaphragm is sensed by an interferometer formed of a light source 110 directing a beam of light via a beam splitter 120 on to the diaphragm. A reference beam is also diverted from the beam splitter onto a photodiode 130.

Light reflected from the diaphragm is diverted by the beam splitter onto the photodiode 130 where it is combined with the reference beam and converted to an electrical signal indicative of changes in the position of the diaphragm. The electrical signal is processed by a thresholder 140 and a delay 150 before being amplified by an amplifier 160.

In other embodiments, two light beams in quadrature phase relationship could be used, to give an improved position sensing facility.

The diaphragm 100 is positioned between two charged plates 170. The diaphragm is electrically conductive, and so an electrostatic force is applied to the diaphragm by the interaction of the signal output by the amplifier 160 (which charges the diaphragm) with the charged plates 170. This part of the device operates in a similar manner to a known electrostatic loudspeaker.

So, by comparing Figures 1 and 2 it can be seen that the microphone acts in the same way as the DSM of Figure 1, except that:

(a) the action of the filter 40 is provided by the mechanical response of the diaphragm 100; and

(b) the action of the comparator 10 is provided by the opposite responses of the diaphragm to incoming sound waves (an analogue signal) and the electrostatic forces applied by interaction with the charged plates 170.

Accordingly, a one-bit signal representing the incoming sound signal is output from the delay 150.

Figure 3 schematically illustrates a microphone according to a second embodiment of the invention.

In Figure 3, several of the parts 100, 140, 150, 160 and 170 are the same as those shown in Figure 2. However, rather than using an optical position sensor to detect the position of the diaphragm, a capacitative sensor is employed.

The capacitative sensing technique makes use of the capacitance between the diaphragm 100 and each of the plates 170. A bridge arrangement is formed by connecting two further capacitors 200, 210, of nominally identical capacitance, across the plates 170.

A radio frequency (rf) source 220 is connected between the output of the driving amplifier 160 and the junction of the capacitors 200, 210. The frequency of the rf source is selected to be well outside of the audio band - perhaps 5 MHz. A differential amplifier 230 is connected across the two plates 170, with its output providing a position signal for input to the thresholder 140 as before.

An equivalent circuit is illustrated schematically in Figure 4, where the capacitance between the diaphragm 100 and the plates 170 is illustrated as schematic capacitors 171, 172.

As the diaphragm moves to one side, one of the capacitances 171, 172 increases and the other decreases. In this standard bridge arrangement, a voltage is developed across the inputs to the differential amplifier 230 indicative of the change in position of the diaphragm. This forms the position signal which is processed as described above with reference to Figure 2.

CLAIMS

1. A microphone comprising:

a diaphragm movable in response to incident sound waves;

a position sensor for generating an electrical position signal indicative of the position of the diaphragm;

a thresholder for generating a one-bit digital signal indicating whether the position signal is above or below a threshold signal level;

a delay for delaying the digital signal; and

a diaphragm driver for moving the diaphragm in response to the digital signal and in an opposite sense to the motion of the diaphragm represented by the digital signal.

2. A microphone according to claim 1, in which the position sensor is an optical position sensor.

3. A microphone according to claim 1, in which the position sensor is a capacitative position sensor.

4. A microphone according to any one of the preceding claims, in which the diaphragm driver comprises one or more electrically charged plates adjacent to the diaphragm, and a driver circuit for supplying an electrical signal to the diaphragm in dependence on the delayed digital signal.

5. A microphone according to claim 4 as dependent on claim 3, in which the position detector comprises means for detecting a change in a capacitance between the one or more plates and the diaphragm.

6. A microphone according to claim 5, comprising two charged plates disposed on opposite sides of the diaphragm, the capacitance between each charged plate and the diaphragm forming a respective arm in a bridge measuring circuit.

7. A microphone substantially as hereinbefore described with reference to Figure 2 or Figures 3 and 4 of the accompanying drawings.

The Patent Office

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Claims searched: 1 to 6

Examiner: Peter Easterfield
Date of search: 26 January 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): H4J (JGC, JGF)

Int Cl (Ed.6): H04R 1/00, 3/00, 9/08, 11/04, 17/02, 19/01, 19/06, 21/02

Other: Online: WPI, JAPIO, CLAIMS

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	US 5051799 A (PAUL et al)	
X	US 4395593 A (FLANAGAN)	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.